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The Optimized NIF Laser System Based on ICF Target Requirements*

S.W. Haney, W.H. Williams, R.A. Sacks, C.D. Orth, J.M. Auerbach,
J.K. Lawson, M.A. Henesian, K.S. Jancaitis, P.A. Renard, J.B. Trenholme

Lawrence Livermore National Laboratory
P.O. Box 808, L-490
Livermore, CA 94550 USA
(510) 422-9182/FAX (510) 423-6506

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Abstract

The design of the National Ignition Facility (NIF) is the result of optimization studies that maximized laser performance and reliability within a restricted cost budget. We modeled the laser using a suite of tools that included a 1D propagation code, a frequency conversion code, a 2D ray trace code for calculating the gain profile, thermo-mechanical codes for calculating the pump-induced distortions in the slabs, a database giving estimates of optics bulk/finish quality, and costing models of the laser/building. By exploiting parallel processing, we were able to consider approximately 750 possible designs per hour using a cluster of 28 workstations. For our optimization studies, we used a temporally shaped (ICF indirect drive) pulse producing at least 2.2 MJ and 600 TW in a 600 micron diameter hole at the target entrance plane. We varied as many as 20 design variables (e.g., slab counts, slab thickness, Nd concentration, amplifier pulse length) and applied as many as 40 constraints (e.g., flashlamp voltage and fluence damage/filamentation at various points in the chain). We did not vary the number of beamlets (fixed at 192) or the aperture (fixed at 40 cm). We used three different optimization approaches: a variable metric algorithm, an exhaustive grid search of more than 50,000 candidate designs, and a parabolic interpolation scheme. All three approaches gave similar results. Moreover, a graphical analysis of the parameter scan data (analogous to sorting and pruning designs using a spreadsheet) has allowed us to understand why the optimizers eliminated alternate designs. The most inexpensive main-switch-boost slab configuration meeting the mission requirements and satisfying all constraints was 9-5-3. The cost of this configuration is approximately $10M less than the 9-5-5 conceptual design. However, the NIF Project has chosen a slightly more expensive 11-0-7 configuration for continued Title I engineering because of its similarity to the Beamlet 11-0-5 design and a lower B-integral.

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